THE

ONTARIO WATER RESOURCES

COMMISSION

INFORMATION REQUIRED AND CRITERIA USED

TO EVALUATE EMBANKMENT RETENTION SYSTEMS

DESIGNED TO IMPOUND SOLID WASTE MATERIALS

DISCHARGED AS SLURRIES

N O T E

This guide has been prepared as an aid in the preparation of applications for approval of industrial waste treatment and disposal systems in which embankment or impoundment is used to prevent or control the discharge of suspended solids.

This is not intended as an interpretation of Commission policy within the meaning of Section 27 and 50 of the CWRC Act, nor as indicating that applications which follow the recommendations of this guide necessarily will be approved.

INTRODUCTION

The processing of unrefined ores, particularly the milling of gold, uranium and base metal ores, produces large quantities of liquid and solid wastes (tailings) which contain concentrations of suspended solids and toxic ions in excess of OWRC objectives for discharge to surface waters in Ontario. It is therefore necessary to impound these wastes, such that their discharge to surface waters is controlled or prevented. Impoundment is usually accomplished by the construction of dyked retention systems with a controlled decant to a surface water. The advantage of this system, apart from pollution control, is that solids are retained for reprocessing, and, in cases where an abundant water supply is not available, the decant can be re-used in the mill circuit.

The size and construction of these retention systems will vary with the production capacity of the mill, the volume of liquid waste produced, the topography of the area and the availability of land for a disposal site. Generally, the location of a retention system is chosen to take advantage of the natural contour of the area, but it is usually necessary to construct an earth and/or tailings dyke at some point to contain the liquid or solid wastes, or both. In the latter case, the liquid and solids are usually discharged to one area within the system so that coarse solids build up in essentially the same area, and the fine solids or slimes and liquids flow toward the centre of the tailings pond area. Tailings embankments are usually constructed by discharging a tailings slurry near the inside edge of the initial earth embankment. The coarse solids rapidly settle out near the initial embankment and the fine solids drain to the centre of the system. When tailings accumulate

to within a few feet of the top of the embankment, the system is extended by depositing coarse solids on the top of the embankment.

It is important that these embankment retention systems be constructed and maintained in accordance with sound engineering principles in view of their purpose to prevent or control the release of objectionable constituents to the receiving stream environment. The Commission has proposed criteria for the construction and maintenance of these earth and tailings embankments, which are principally derived from the requirements of the United States Atomic Energy Commission for the licensing of disposal systems for uranium ore processing wastes.

It is the purpose of this guide to specify in detail the information which the Commission will require in connection with the issuance of certificates of approval for industrial waste treatment works specifically related to tailings disposal areas, and to identify the criteria for their construction and maintenance that will be used in evaluating such systems. The criteria are necessarily general in nature since the characteristics of embankment systems may vary significantly from one location to another. However, these criteria should not be considered as relieving an applicant of his responsibility for ensuring that his system is adequate from a structural and pollution control standpoint.

The Commission may request additional information from applicants if such information is necessary to provide reasonable assurance that the applicant has established an adequate system. Such requests may be avoided by a thorough study of Commission objectives and this guide prior to submission.

An applicant may incorporate, by reference, information contained in applications, statements and reports previously filed with the Commission's Division of Industrial Wastes, provided that such references are clear and specific.

INFORMATION REQUIRED

In addition to the information required by Section 31 of the OWRC Act, as outlined in the application form, the following information should also be included:

(a) Drawings showing the layout in plan; typical cross-sections of all embankments showing proposed design, and if applicable, anticipated future extensions; and other pertinent design details. Embankment design should include information on heights, top width, side slopes, freeboard, seepage control, and protection of embankment surfaces as well as foundation design.

(b) A design analysis of the integrity of the proposed system including, as applicable, the results of soil tests, geologic exploration, nature of foundation materials, stability investigations and characteristics of fill material as well as a description of the construction methods and specifications.

(c) An evaluation and discussion of conditions that might lead to accidental release of the waste, the probable environmental effects of such release, and proposed program of inspection and maintenance to prevent such an accidental occurrence.

EMBANKMENT RETENTION SYSTEM CRITERIA

The Commission will take the following factors into consideration in evaluating for approval, the information submitted by an applicant:

A. Location

1. The site should be subject to the complete control of the applicant so as to permit entry only of authorized personnel thereto.

2. The site should not occupy the channel of any permanent watercourse unless a provision has been made for permanent diversion of such watercourse around the site.

3. The site should be permanently protected against runoff from the surrounding drainage area by the provision of diversion channels to prevent such runoff from entering or washing out the embankments.

4. A minimum distance of 200 feet should be maintained between the embankments and any permanent flowing watercourse at flood stage to minimize percolation effects, unless information is submitted for satisfying a closer location.

B. Design

1. Foundations - Foundations should be investigated to determine that they have suitable strength and permeability characteristics for the embankment proposed, including anticipated future extensions. A foundation of rock or graded sand and gravel is normally considered to have satisfactory strength for small embankments (under 25 feet in height). Foundations of alluvial deposits, which have not been consolidated under appreciable loads, and those of fine and uniform sands, or of plastic clays, must be given careful investigation and treatment to ensure safety of the embankment.

2. Embankments

   (a) Construction material - The embankment material used in the construction of earth embankments may be natural soil, usually barrow soil found nearby, suitable for the construction of such systems. Coarse tailings material may be used to extend an earth embankment provided design and construction methods specified in this guide are followed.

   (b) Top width - The minimum top width of an embankment should be eight feet. As the height of the embankment increases, the top width should be increased as specified in Table I below. It may be necessary to further increase the top width if the embankment material is susceptible to erosion or sloughing.

TABLE I - RECOMMENDED MINIMUM TOP WIDTH FOR EMBANKMENTS

Height of Embankment (feet)	Minimum Top Width (feet)
8 to 12	10
13 to 20	12
21 to 30	15
Over 30	20

(c) Side slopes - In most cases, the type of material that is readily available for embankment systems will require that side slopes on the upstream face (i.e. in contact with the liquid) have a slope ratio between 4 to 1 and $2\frac{1}{2}$ to 1, and on the downstream face of the embankment between 3 to 1 and 2 to 1. Table II below contains recommended maximum slopes for embankments constructed of various materials.

TABLE II - RECOMMENDED HORIZONTAL TO VERTICAL SIDE SLOPE RATIOS FOR EMBANKMENTS

Embankment Materials	Upstream Face	Downstream Face
Homogeneous Sandy Clay	$2\frac{1}{2}$ to 1	2 to 1
Coarse Sand with compacted clay or structural core wall	3 to 1	$2\frac{1}{2}$ to 1
Sand-gravel mixture with compacted clay or structural core wall	3 to 1	2 to 1
Homogeneous Silty Clay	4 to 1	3 to 1
Homogeneous Sandy Loess	3 to 1	3 to 1
Coarse Tailings (dry)	$2\frac{1}{2}$ to 1	2 to 1

Where coarse tailings material is used to increase the height of an initial earth embankment, the Commission will consider the material as purely frictional with an angle of internal friction of 33 degrees (i.e. a natural slope of approximately $1\frac{1}{2}$ to 1). This will mean that the downstream face of the embankment should have a total slope ratio of approximately 2 to 1. Berms may be employed in the construction of the embankment to satisfy this side slope ratio, provided the berms are at least eight feet in width, the height of each embankment section does not exceed 18 feet, and the slope of each tailings embankment section is at least the natural slope of the material.

The recommended slopes in the above table may have to be flattened when necessary to spread the load so that the maximum unit stress induced in the foundation will be less than the shear strength of the foundation material or when full knowledge is not available on shear strength and seepage flow.

(d) Freeboard - The freeboard height of the embankment above the maximum liquid level should not be less than three feet. Consideration should be given to future compaction and settlement of the embankment and to frost penetration which would materially effect the possible freezing and cracking of the embankment above water level.

3. Seepage Control - Suitable methods should be employed to minimize the effect of seepage on the embankment and its foundation. Methods of controlling seepage include toe drains, filter layers, impervious cut-offs or blankets, and corewalls. Seepage along the contact surface between the foundation and the embankment should be minimized by removal of all organic material such as sod and top soil, and, where appropriate, the installation of a "key" trench.

4. Protection of Embankment Surfaces - Embankment surfaces should be protected against erosion by the use of such means as vegetation, berms, logs, or riprap. The method of protection used must be based upon the susceptibility to erosion.

5. Protection Against Environmental Release - Where deemed necessary, provisions such as the use of additional surrounding embankments or sumps should be made for capturing or holding liquid waste resulting from seepage through the embankment or unexpectedly released by failure of the primary embankments.

   Unprotected surfaces on the top or within the retention system, such as inadequate crust formation, should be provided with an effective means of dust control, such as a sprinkler system for periodically wetting down these surfaces, a form of cement or asphalt binder for a more permanent sealer of the surfaces, or vegetation if found feasible.

C. Construction Methods

Construction of the embankment should be started only after clearing and grubbing operations are completed and the foundation has been properly prepared. Embankment material should be free of sod, roots, stones over six inches in diameter, and other material which might interfere with proper compaction. Frozen material should not be placed in embankments and embankments should not be constructed on frozen foundations. The

placing and spreading of embankment material should be started at the lowest part of the section under construction and the embankment carried up in horizontal layers not exceeding eight inches in thickness. Insofar as possible, these layers should be of uniform elevation and extend over the entire area of the fill. The distribution and gradation of materials throughout the embankment should be such that there are no lenses, pockets or streaks created, and the moisture content of the materials should be proportioned for maximum degree of compaction. Proper compaction of the embankment material should be achieved by the use of equipment designed for this purpose, usually a sheepsfoot roller. The travel of excavating equipment is generally not considered an adequate method for obtaining compaction. If the sheepsfoot roller is used, it should be weighted to give a unit pressure of not less than 200 pounds per square inch of the total surface area of the feet simultaneously in contact with the embankment. Usually six passes of the roller over each individual layer of material are sufficient to obtain good compaction. For relatively low embankments, under 25 feet in height, the adequacy of compaction may be determined by observation of the roller in action. For embankments over 25 feet in height, field control over compaction should be more precise and the embankment should be rolled until some predetermined degree of compaction is obtained, usually 90 to 95 per cent of maximum density as determined by appropriate compaction tests.

Tailings embankments should be started with an initial outer earth embankment as described above and may be raised when necessary by using coarse tailings material. The tailings, usually in the form of a slurry, should be deposited within the system in such a way that coarse sands settle out first near the embankment, while the fines or slimes are carried away toward the liquid pond area where the liquid is retained. Observations should be made and records kept of the deposition of tailings as well as sampling of the tailings near the embankment to determine its properties for use in building up the embankment. In order to gain the maximum shear strength from this material, it should be kept as dry as possible during embankment extension and all subsequent seepage flow should be minimized. Proper construction methods, including compaction, should be observed as specified above.

D. Maintenance and Inspection

A program of maintenance and inspection should be established to detect and repair environmental and other effects which might tend to lessen the integrity of the embankment system.